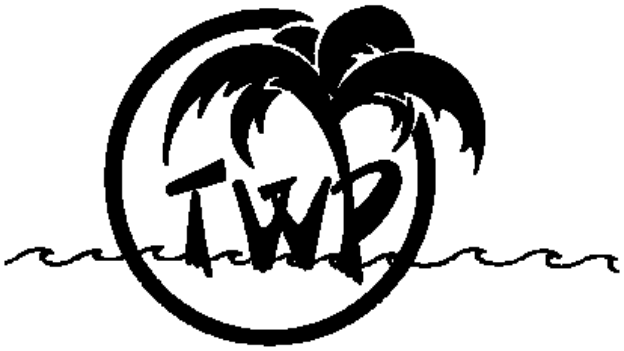
Tropical Western Pacific

Site Science Mission Plan

July - December 1998



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CONTENTS

PREFACE

The purpose of the TWP Site Scientific Mission Plan is to provide information for the planning of scientific activities in the TWP locale. It will update the status of the locale at six month intervals with a detailed projection for the next six months as well as longer term views when appropriate. All acronyms used are defined in the Acronym Section.

These plans are available on the ARM homepage at:
www.arm.gov.

Printed copies can be obtained from either:

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INTRODUCTION

The Department of Energy's Atmospheric Radiation Measurement (ARM) program was created in 1989 as part of the US Global Change Research Program to improve the treatment of atmospheric radiative and cloud processes in computer models used to predict climate change. The overall goal of the ARM program is to develop and test parameterizations of important atmospheric processes, particularly cloud and radiative processes, for use in atmospheric models. This goal is being achieved through a combination of field measurements and modeling studies. Three primary locales were chosen for extensive field measurement facilities. These are the Southern Great Plains (SGP) of the United States, the Tropical Western Pacific (TWP), and the North Slope of Alaska and Adjacent Arctic Ocean (NSA/AAO), as shown in Figure 1. This Site Science Mission Plan [RPT(TWP)-010.003] describes the ARM program in the Tropical Western Pacific locale.

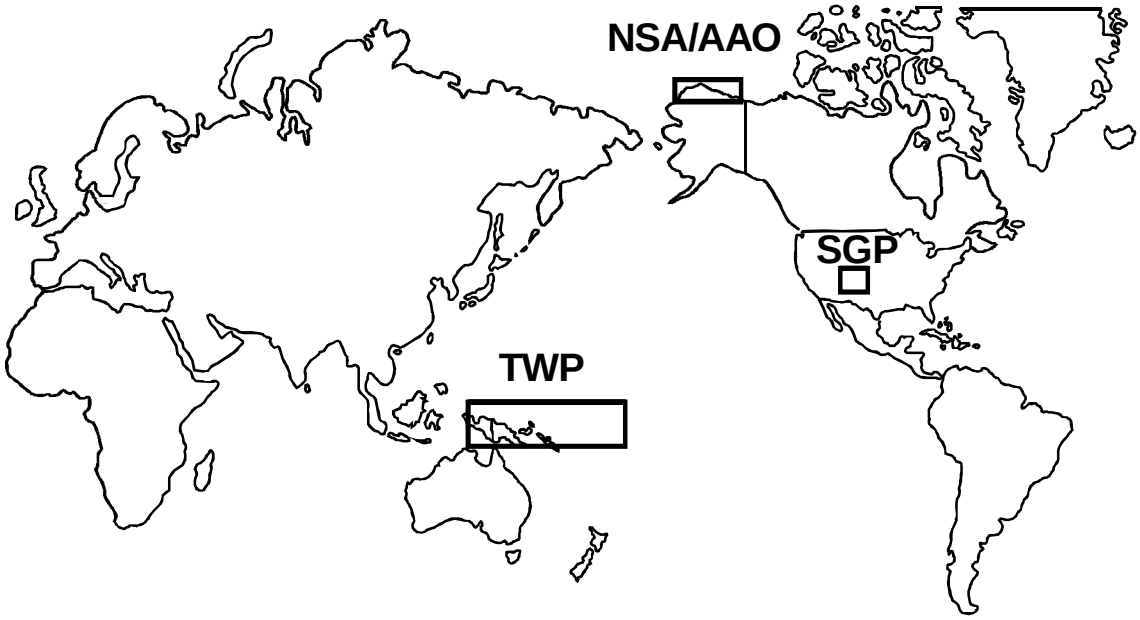

Fig.1. Locations of the three primary ARM locales.

The Tropical Western Pacific locale is the second site to be instrumented by the U.S. Department of Energy's ARM program. The TWP locale, shown in Fig. 1, encompasses the area from 10°N to 10°S of the equator and from Indonesia to east of the international dateline. The locale was selected[1] because of the existence of the Pacific warm pool, the resulting cloud formations, and its influence on weather and climate throughout the planet. The purpose of the TWP program is to collect long-term data to better understand the effect of tropical clouds on the earth's

[1] U. S. Department of Energy (DOE), 1991. Identification, Recommendation, and Justification of Potential Locales for ARM Sites. DOE/ER-0495T, National Technical Information Service, Springfield, Virginia.

energy budget. The overall science objectives and measurement strategy for the TWP are given in ARM Science Plan[2].

Currently TWP program plans to implement three island-based sites (Fig. 2) with Atmospheric Radiation and Cloud Stations (ARCS) by the year 2001. In addition the TWP program is pursuing ways of obtaining data over the open ocean in the locale with instrumented buoys and ship studies. These data along with satellite data will constitute the basic ARM TWP data set. Intensive operational periods (IOP), campaigns, and collaborations with other studies in the locale will occur as the site matures.

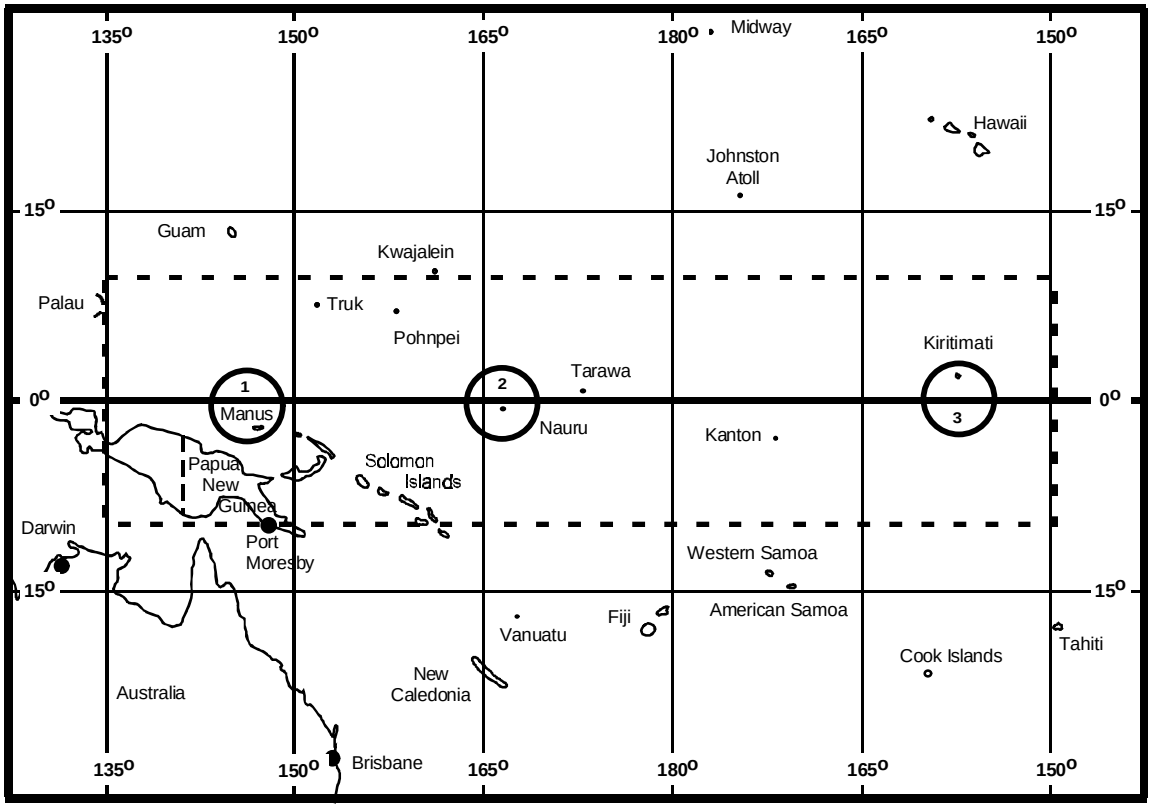

Fig. 2. Equatorial Western Pacific region showing TWP locale (dashed area) and proposed ARCS sites (circles).

SCIENCE GOALS

The basic science goals of the Tropical Western Pacific component of the ARM program are:

[2] U. S. Department of Energy (DOE), 1996. Science Plan for the Atmospheric Radiation Measurement Program (ARM). DOE/ER-670T, National Technical Information Service,

1. Determine the magnitude of the surface radiation budget terms and determine their spatial and temporal variability.
2. Identify bulk and optical properties of clouds in the TWP and how these properties affect the radiation budget.
3. Understand the linkages among sea surface temperature, ocean-atmosphere coupling, surface radiation budget, and tropical convection.
4. Determine vertical transports of water vapor, energy, and momentum in convective cloud systems.

These goals represent a sequence of increasing complexity of knowledge, as well as increasing complexity of measurement. The first is fundamental. We have relatively incomplete knowledge of the surface radiation budget in the TWP, particularly over periods of time longer than a month or a few months. Similarly, high-resolution measurements of bulk cloud properties in the TWP have only been made for short periods of times during campaigns or research vessel cruises. Further, data sets to establish the effect of clouds on the radiation budget do not exist. The third goal seeks to understand the processes in the TWP that connect surface fluxes, sea surface temperature, and convection. These connections are at the heart of meteorology in the TWP and must be well understood for both short-range and long-range climate modeling. The fourth goal represents the linkage between cloud systems and the larger circulation patterns of the region. In addition, it encapsulates cloud feedback processes as they impact the surface radiation budget and sea surface temperature.

The TWP area of interest to ARM is very large, mostly ocean, logistically remote, and operationally costly. Consequently, ARM operations in the TWP will be more limited in scope than in some other locations. Achieving the scientific goals will require a careful blending of long-term, surface remote sensing observations with field campaigns and satellite observations. The Atmospheric Radiation and Cloud Station (ARCS) currently operating at Manus Island, PNG, is the first step in the acquisition of long-term data on surface radiation budget and cloud properties. The planned deployment of additional ARCS on Nauru and Kiritimati islands will further enhance this acquisition.

The ARM TWP team carefully selected the ARCS instrumentation to address the issues raised by the first two goals. A list of ARCS measurements and instruments is given in Table 2. Detailed information on the various instruments is available on the ARM homepage: www.arm.gov. The system measures all components of the surface radiation budget. The system currently measures only cloud-based heights and cloud base temperature or cloud emissivity, depending on the cloud thickness. The program plans to upgrade the cloud measurements to include cloud top, as well as base height, and cloud fraction. In addition, routine measurements of the atmospheric base state are acquired with radiosondes, profilers, and surface meteorological sensors. A summary of the data acquired by the Manus ARCS

during this current period is given in Section 1.2.1. We encourage members of the scientific community to access that data and use it in their research.

Table 1. ARCS Measurements and Instruments

Measurement	Instruments
Surface radiation balance	• Up- and down-looking pyranometers and pyrgeometers • Sun-shaded pyranometer and pyrgeometer • Normal incidence pyrheliometer • Up- and down-looking 9-11μm narrow field of view radiometers • UV-B hemispheric radiometer • Broad band (solar and infrared) net radiometer
Surface meteorology	• Temperature and relative humidity sensor • Barometer • Optical rain gauge • Propeller vane anemometer
Cloud properties	• Cloud lidar (523 nm) • Ceilometer (7.5 km maximum range) • 35 GHz radar [a] • Whole sky imager [a]
Aerosol optical depth	• Multi-filter rotating shadow band radiometer (total, direct, and diffuse irradiance in six 10 nm channels)
Column water	• Dual channel (23.8 and 31.4 GHz) microwave radiometer
Vertical structure of the atmosphere	• Rawinsonde • 915 MHz wind profiler with RASS[b]
a - Not currently installed	b - Operated in cooperation with NOAA's Aeronomy Lab

Siting Strategy

An important property of the climate in the tropical Pacific is a strong east to west gradient in various climate parameters including sea surface temperature, water vapor column, and frequency of convection. The Tropical Western Pacific is characterized by high sea surface temperatures and frequent, and deep convection. Toward the eastern Pacific, there is a steady decline in sea surface temperature and a corresponding decrease in the frequency of convection. Because of this longitudinal structure and its variability it would be difficult to characterize the climate of the tropical Pacific with a single site. The plan for ARM in the TWP is to deploy an ARCS at three sites to sample the structure in this region, as shown in Fig. 2.

The deployment schedule and status of the sites are given in Table 3. The current implementation plan calls for the TWP locale to be fully operational by 2001. ARM and South Pacific Regional Environment Programme (SPREP) are working closely together in siting, public awareness, educational, and other aspects of implementing the TWP locale.

Table 2. TWP ARCS Sites Proposed Schedule and Status

	Site	Latitude	Longitude	Start Date	Status
1	Manus	2.060°S	147.425°E	1996	Operations began in October 1996
2	Nauru	0.521°S	166.916°E	1998	Operations to start in November 1998
3	Kiritimati	1.87°N	157.33°W	2000	Planned

1.0 MANUS SITE, PAPUA NEW GUINEA

The first TWP site is in Manus Province, Papua New Guinea (PNG). This site was chosen because of its location within the heart of the Pacific warm pool, the existence of a NOAA Integrated Sounding System (ISS), and the support of the PNG National Weather Service (NWS). The site is located at the NWS station at the Momote airport on Los Negros Island at 2.060°S, 147.425°E (Fig. 3).

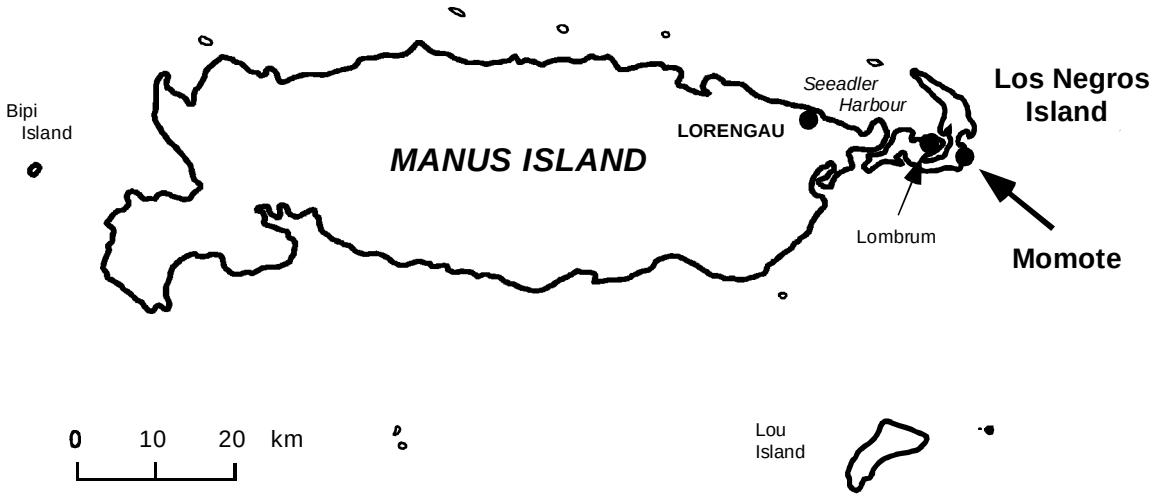

Fig. 3. Manus Province, Papua New Guinea. The ARCS is located at the National Weather Service station at the Momote airport on Los Negros Island.

The site is 6 meters above sea level. The highest point on Manus Island is 702 m, but most of the island has an elevation of less than 200 m. The highest point on Los Negros Island is 121 m but within 3 km of the site the elevation is less than 20 m. All equipment is located within the National Weather Service compound at Momote (Fig. 4). The siting, installation, and operation of the Momote site is a collaborative effort between ARM TWP and the PNG National Weather Service.

Fig. 4. ARCS installation at National Weather Service station at Momote airport, Manus Province, PNG.

1.1 Manus Operations

ARCS-1 was installed at Momote during August and September 1996. It was shipped from Long Beach, California on 22 May and all components were on site by 07 August. Installation began on 24 August and took 6 weeks and 435 man-days of work for completion. The site was formally commissioned on 12 September and routine operations began on 8 October. PNG NWS staff is in charge of the daily operations of the site. Assistance in performing these duties and in troubleshooting problems is provided by the TWP Operations Center in the US. Communication between the site and the Operations Center is conducted by phone, fax, and satellite. A REgional SErvice Team (RESET) visits the site periodically to perform maintenance and calibration. These routine visits are nominally scheduled at six - month intervals. Additional visits are made when required. Appendix A shows the Manus site layout of instruments and facilities.

Operation of the Manus site is managed out of the TWP Operations Center at Los Alamos National Laboratory in collaboration with the Papua New Guinea National Weather Service.

1.1.1 Manus Operations Status

The Manus site has been operating since 8 October 1996. Currently all planned instrumentation except the cloud radar are installed and operating. Helium is being used as the lift gas for the once per day balloon borne sounding at 00Z (1000 Mountain Standard time). Health and status data are transmitted hourly from the site to the ARM Experiment Center via the GOES satellite system. All data are returned on tape monthly by courier service. Locally, three PNG NWS personnel operate the site.

RESET Visits:

A Regional Service Team (RESET) visit consists of two or more TWP technicians and is classified as either routine or non-routine visits. Routine visits are primarily aimed at instrument calibration, observer training, and semi-annual maintenance. They are scheduled at 6-month intervals. Non-routine visits are for special retrofits or emergency repairs and can be initiated at any time.

During January through June 1998 TWPPO conducted two RESET trips to the Manus site.

RESET-Special: (February 1998, 2 weeks, 4 people). This was a non-routine visit focusing on the installation of RACE (and prep for future SAM installation) and the Inmarsat B Satellite communication system. The team also upgraded the ADaM data processing system and upgraded the DC power system to eliminate solar power dependency. The MPL diode was also replaced.

RESET-3: (April 1998, 2 weeks, 3 people). This was a routine visit for general instrument change out, calibration and comparison testing. Another important task was the replacement of the MPL diode.

Significant Events

Below are significant operational events that occurred during the January – June 1998 period. The sequential labels (MAS-SE-N) indicate the Manus (MAS) Significant Event (SE) and number (N). A record of all events is available on the TWP website at: www.twppo.lanl.gov.

MAS-SE-8: HRPT satellite system upgrade:

During the RESET-2 visit a color printer was installed on the HRPT satellite receiving system at the NWS headquarters in Port Moresby. A software upgrade was also installed and NWS staff was instructed in new operational procedures.

MAS-SE-9: I-Van UPS fails:
On January 6, 1998, the UPS system for the I-Van stopped working. The stand-alone instruments require this system to operate. An extension cord was run to the D-Van UPS that was still operating. This was subsequently fixed at a later RESET Visit.

MAS-SE-10: MPL malfunctions:
The MPL diode was replaced on February 6, 1998 during the RESET-Special because of instability noticed earlier. But on February 17, 1998 the MPL started shutting off every half-hour. The laser diode was replaced again during RESET-3 on April 20, 1998.

MAS-SE-11: Ceilometer reporting problems:
The Ceilometer computer required regular rebooting to enable it to report Ceilometer data to ADaM. It stopped working altogether on February 21, 1998. A new Ceilometer computer and software were installed on April 21, 1998 during RESET-3.

MAS-SE-12: X-Van vandalism:
The X-Van (extra) was broken into on the night of February 25, 1998. The portable generator, some tools, and other miscellaneous supplies were removed. The spare Brusag Tracker was moved, but apparently not damaged.

1.1.2 Manus Operations Projection

RESET-4 Visit: During the July – December 1998 period there will be one scheduled RESET visit to perform upgrades and repairs as follows:

- **Whole Sky Imager Installation:** The Whole Sky Imager for the Manus site is currently at the ARCS integration site in Albuquerque undergoing modifications and testing. It will be shipped to Manus and installed.
- **UPS Repair:** The UPS system for the I-Van went down and needs repair. This is very important since without it we are vulnerable to a complete shutdown of the entire site. New UPS modules and batteries will be shipped to Manus for installation at RESET-4.
- **ADaM Tape Drives:** The ADaM system tape drives are misaligned and are producing damaged data tapes. They need to be replaced to assure reliable data collection and its delivery to the ARM Experiment Center.

1.2 Manus Data Quality

The TWP Site Science Office at Penn State University reviews all TWP data before being released for use. Data quality is assessed in two stages. First, the site transmits data via GOES satellite each day. This message includes hourly statistics (mean, maximum, minimum, and standard deviation) of most data streams. These data are automatically plotted each day and manually inspected for problems by the site science office. Full examination is reserved for the arrival of the complete tape data set.

Once the full data set is retrieved, all the data is plotted using a set of Matlab tools developed at Penn State. These plots include simple daily plots of the raw data and diagnostic plots of instrument to instrument and instrument to model comparisons.

1.2.1 Manus Data Quality Status

We have three specific goals related to the analysis of data quality.

1. Completely describe the existence of the data: Report the periods when the instrument produced data for each instrument. We have organized the information derived from this analysis so that it will be easy to determine what instruments were operating for any given period or, conversely, to determine for which periods a certain set of instruments were operating.

Table 3: Data Gaps during 1998 at the Manus Site

Instrument Platform	Operational Period	Total Days Missing Data
SKYRAD	Jan. 1 - Jun. 19	12.6 (1)
GNDRAD	Jan. 1 - Jun. 19	9.4 (1)
SMET	Jan. 1 - Jun. 19	11.0 (1)
MFRSR	Jan. 1 - Jun. 19	39.7 (2)
MWR	Jan. 1 - Jun. 19	17.1
MPL	Jan. 1 - Jun. 19	57.5 (3)
VCEIL	Jan. 1 - Jun. 19	94.8

Notes:

1. The SKYRAD, GNDRAD, and SMET loggers each experienced periodic gaps of 1 to several hours as result of a problem with the configuration of the data collection software. This problem began in February and persisted until early May.

2. Nearly all the MFRSR gaps came during an extended period of downtime at the beginning of the year. The instrument was brought back on line during a RESET visit on February 7.

3. The MPL experience significant downtime because of problems with the laser diode supply. The supply was replaced during a RESET visit in May. Prior to that time, the MPL would operate for a few hours to a day, then would quit. So there are many gaps during this period.

4. The Ceilometer has experienced numerous short gaps as well as several extended ones. The longest extended gap occurred during the period February 21 to April 19. Other extended gaps include January 5-8, February 5-7, May 25-30, and June 11-15.

2. Note obvious data outliers: For each data stream, we are identifying some criteria that describe what constitutes reasonable data. We are going through all the data streams and noting where the data contradicts these guidelines.

3. Note more subtle data issues: Wherever possible, we are comparing similar data streams. For example: the NIP can be compared with the difference of the total and diffuse Eppley PSPs; the two up-looking PIRs (one shaded and one not) can be compared; the Net Radiometer on the GNDRAD stand can be compared with the net irradiance calculated from four broad band Eppley radiometers; the down-looking PIR can be compared with the down-looking IRT; the microwave radiometer can be compared with integrated water vapor; and the two anemometers on the meteorological tower can be compared.

During this reporting period we have become aware of several issues that impact data quality or data existence. The most serious of these has been the short lifetime of the MPL laser. The RESET team visits the Manus site at approximately six-month intervals. We became aware this spring that when run continuously, the MPL pump laser - or laser diode supply is only specified to operate for a little over six-months. Since this is not a part that can be replaced by the local weather service staff, this short lifetime implies that the laser should be replaced at each RESET visit. Even after replacing the laser, we have seen problems crop up after periods as short as a week. Thus we have experienced considerable down time with the MPL.

Another significant problem occurs with the MFRSR. The MFRSR has six narrow band filtered channels. These filters are subject to drift, altering the calibration of their respective channels. This change in the calibration can be significant (a factor of ten or more) and can occur rapidly (over the course of a few weeks). Under conditions where clear skies occurred frequently, such a drift could be accounted for because Langley regressions of the top of atmosphere narrow band flux could be used to track the change. However, in the TWP, clear skies are rare. Thus it is difficult to obtain frequent enough Langley regressions to compensate for the filter drift.

There are two problems with the MWR that effect the data. The heater that is meant to dry the Teflon window has failed several times. Without this heater, it takes up to about half a day for the window to dry. When there is water on the window, the MWR data cannot be used. During such periods, the retrieved vapor and liquid appear to decay with time constants of 10s of minutes to a few hours. This is a serious problem when the heater is not working during extended rainy periods.

The other issue with the MWR is less serious. It seems that when the sun is directly overhead, there is a considerable bias in the retrieved vapor and liquid. This problem occurs for approximately 30 minutes about local noon for approximately 2-3 weeks in the fall and spring.

1.2.2 Manus Data Quality Projection

The TWP site science team is actively involved in an inter-site effort to improve and standardize QC analysis throughout ARM. We are working with individuals from the NSA and SGP site science teams as well as the ARM data system team on a variety of QC issues. At our office we are working most directly on the development of automated and manual flagging procedures. We have begun a pilot project with the short wave instruments to show proof of concept. We have codes in hand that flag short wave data automatically - we now need to optimize these codes to provide the most useful information to the various users (the science team for data selection and mentors and site scientists for trouble shooting).

The manual part of the QC process is done with DQRs. Through many recent discussions, we are working to optimize the manual entry (and subsequent retrieval) of QC information. We hope to structure the manually entered metadata in such a way that it can be automatically merged with the automated flags to produce an overall picture of data quality. We also need to work with the programmers who are developing QC display tools to optimize how we display the QC information for users. All of this will take considerable work, but there are many people committed to working on the problem.

2.0 NAURU SITE, REPUBLIC OF NAURU

This second TWP site will be on Nauru Island in the central Pacific (Fig. 2). The Nauru site was chosen because of its location on the eastern edge of the warm pool and its variable climate associated with ENSO events. Also its small size and isolation suggest that its climate should be strongly oceanic. The Republic of Nauru has agreed to host the site; operations will be a collaborative effort between ARM TWP and the Nauru Department of Island Development and Industry. The ARCS will be installed in the Denigomodu District near the General Hospital on the west side of the island at 0.522 °S, 166.913 °E, 7m MSL (Fig. 5). Site preparation is underway. Installation of ARCS-2 is scheduled for September-November, 1998.

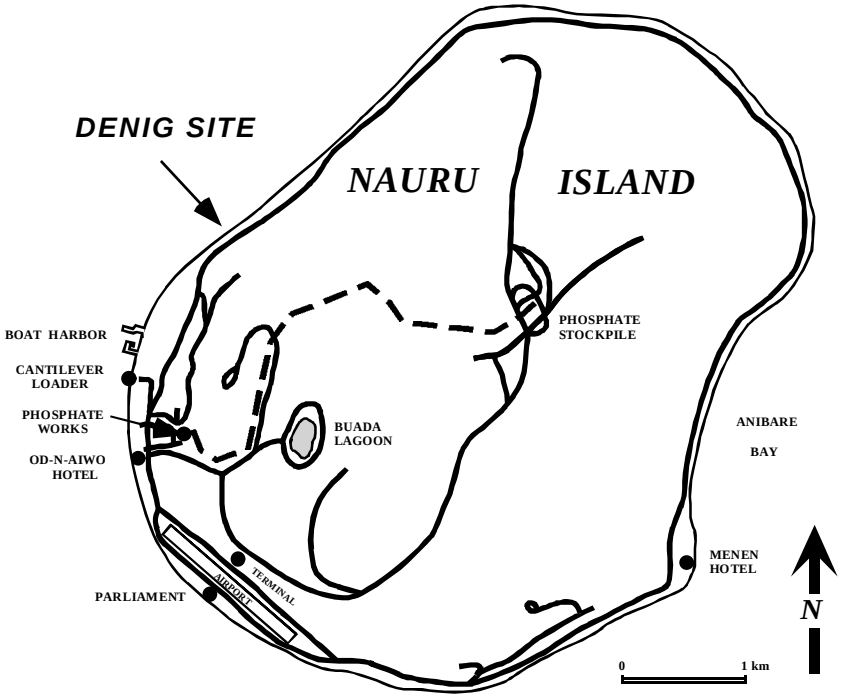

Fig. 5. Nauru Island. ARCS-2 will be located in Denigomodu District on the western shore.

3.0 SITE 3

We would like to locate the third ARCS site in a region normally well out of the warm pool. A possible candidate for the third site is Kiritimati Island (1.87°N, 157.33°W; Fig. 2). Discussions have begun with the Kiribati government concerning this possibility. We would like to begin operations of the third site in 2000.

4.0 IOPs, CAMPAIGNS, AND OTHER COLLABORTIONS

No IOPs or campaigns are scheduled during July through December 1998. A campaign (Nauru 99) offshore of Nauru Island (site of ARCS 2) is being planned for the summer of 1999. The scope of the campaign is dependent on funding, but JAMSTEC has scheduled the MIRAI for six-weeks of measurements. We anticipate the NOAA ship R/V RON BROWN will also participate. The Nauru Science and Implementation Plan can be found at www.etl.noaa.gov/nauru99 under Expeditions.

5.0 OCEAN PROJECT

The goal of the ARM TWP Ocean Project is to provide a means by which ARM can obtain data that apply to the oceanic environment and supplement the

measurements taken at the TWP island stations. The ARM Ocean Working Group (AWOG) was formulated to create a means of focusing the ARM ocean activities. The primary scientific issues suggested by this group are:

- spatial variability of radiation and all fluxes in the oceanic heat budget;
- lower atmospheric mixed-layer physics;
- upper-ocean mixed-layer physics;
- island-induced errors;
- spatial and temporal variability in the sea-surface temperature (SST); and
- cycles of convection on all spatial scales.

In keeping with the ARM Science Plan for the TWP, both intensive field campaigns and long-term measurements of properties and fluxes at the ocean-atmosphere interface will be considered. As these activities require access to floating platforms, both ship and buoy observation systems are under development.

More information on the Ocean Project can be found at www.armocean.bnl.gov.

TAO Buoy Radiometer Program

ARM is participating in the international Tropical Atmosphere and Ocean (TAO) buoy program in the Pacific Ocean. With ARM support, the NOAA Pacific Marine Environmental Laboratory (PMEL) has developed a special digital version of the Eppley PSP for use with their next generation ATLAS buoy package.

Four prototype TAO-PSP radiometers have been operating successfully since June 1997. The daily average insolation values, transmitted via the ARGOS satellite, are most encouraging and it appears the internally stored, 2-minute averages will produce a good test of short-wave irradiance measurements. The program then deployed radiometers and rain rate sensors on all seven buoys along the 165E longitude line from 8N to 8S and all were measuring short wave radiation and rainfall in January 1998.

JAMSTEC is in the process of deploying their TRITON buoys at sites west of 165E. These buoys, which will eventually replace the NOAA buoys, will also have high quality radiation sensors, the Woods Hole IMET sensors. The TRITON buoys will completely replace all NOAA buoys west of 165E* in the next few years and it is essential that ARM establish connections to this data set to provide a good inter-comparison and added coverage in the TWP.

Instrumentation Development

Several instruments, under development for Volunteer Ship Observing System (VSOS) activities worldwide, are being considered for ARM/TWP observing platforms. A Fast-Rotating Shadowband Radiometer has been developed at BNL and was operated successfully on the CSP and TOCS cruises. A multi-frequency version was developed and deployed on two cruises in 1998. A marine version of the AERI, called M-AERI, has been developed by the University of Wisconsin and is operated by the University of Miami on several ships. A simple infrared thermometer has been used to successfully measure SST to the required +/-0.01 C accuracy. Engineers at BNL are working with scientists at Univ. of Colorado to develop this into a low-cost, unmanned system for the VSOS effort. A series of field inter-comparison studies are planned with the goal of achieving an optimum measurement system for the volunteer ship network worldwide.

6.0 EDUCATIONAL OUTREACH

Plan Overview

DOE mandates that its programs have some form of educational outreach program. From the first days of ARM, developing the education outreach program has been assigned to each CART site. A small but consistent funding base has been allocated for the development of the education program, and it is usually administered by the Site Scientist and/or the Site Program Manager. The content of the site education program, while at the discretion of each site, must be relevant to the communities around each CART site.

The TWP presented us with unique problems for developing an education plan. The three TWP sites are spread out over a huge geographic area, and each site is in a different country with a unique language and culture. More importantly, the local schools generally lack advanced technology, such as Internet capabilities. Many do not have TV, video, or film resources and some are lacking the material, infrastructure and educational resources that are considered to be standard in the US. Our goal has been to identify the various educational needs in the communities close to each site, and to attempt to deliver enrichment opportunities to satisfy some of those needs.

The overall vision for the TWP education outreach plan is to enrich primary, secondary and college science programs in the TWP region with a focus on basic science, climate, climate change and effects relevant to the region. The TWP educational outreach plan must have a broad scope to address local, national and regional issues and needs, and be flexible to stay current and relevant over the potential 10-year operating period of the TWP locale. The program must include both technical training for on-site staff, and public education and outreach for local

communities, as well as addressing the needs of the more formal education systems of communities.

Plan Goals

- **Needs Assessment**: Meet with local and regional educators to determine the ways we can support educational needs for communities and the region. Needs assessment must be an ongoing task.

- **Curriculum Development**: Develop a regional curriculum for enriching science curricula in the secondary schools in collaboration with SPREP and other organizations.

- **Curriculum Implementation**: Develop and implement workshops to assist education departments using the curriculum. We will focus first on the communities and education departments close to the TWP sites, but will also participate in regional implementation efforts**.**

- **SPaRCE (Schools of the Pacific Rainfall Climate Experiment)**: Support the SPaRCE program through assisting in the enrollment of schools in the program, support for development of automated school weather stations and advanced equipment, and also in participation in and joint sponsorship of in-service training.

- **Newsletters**: Set up periodic newsletters for schools and for public information. These newsletters will have information on ARM and TWP progress, information on climate issues with a regional focus (e.g. El Niño) as well as a Q&A section for readers to submit issues and concerns.

- **Material Support**: Support (as needed and as funds available) the improvement of material and equipment in the schools close to the ARCS sites. This material support may include books, video resources, computer usage, and simple automated weather stations and equipment.

- **Teacher Training**: Support (as needed and as funds are available) enrichment for teachers including attendance at meetings, and other in-service training.

- **ARM Resources**: Support tours of the ARCS, access to TWP and ARM data, and help with data analysis. TWP scientists and technicians will visit schools and give presentations to faculty and classes on the ARM program; we will assist on occasion with local needs for computer support or equipment issues.

- **Public Relations**: Develop a public relations plan in conjunction with on-site colleagues in the relevant government departments. Activities may include town meetings, local events, site tours, radio or TV interviews. The TWP program goal

is to be responsible and communicative about ARM activities, and to assist with building local capacity for addressing climate and other environmental issues

- **Technical Training**: Develop a technical training plan in conjunction with the on-site staff, the staff supervisors or employers, and the TWP program office. Build on existing technical skills, and offer opportunities for training that might not normally be available to the technical and management staff assisting with the day-to-day operations of the ARCS. The training will be initially to train on-site staff to operate the equipment at the site; followed by side-by-side working and training with TWP technicians, engineers and scientists and, depending on funding, could include formal training given by another provider.

Plan Implementation Summary: 1993 - June 1998

Plan Element	Progress to Date	Planned: July-Dec 98
Needs Assessment	• Meetings with educators and members of the provincial government in Manus Province, Papua New Guinea: 93, 94, 95, 96; with educators in Nauru: 95, 96, 97, 98.	• Continue discussion with Manus and Nauru education depts. • Initiate discussion with educators at the third TWP site after site selection.
Curriculum Development	• Initial 1995 meetings with Nauru Dept. of Ed. identified developing a regional curriculum as high priority. • Meetings 10/95 in Adelaide, Australia, with SPREP and the National Tidal Facility, to initiate curriculum development. • Funding available to both organizations to continue the work. • Assisted with meetings in 1996 at SPREP in Samoa to further develop workshops. • Curriculum published 1998 by SPREP.	Complete.
Curriculum Implementation	• Began plans to develop and implement workshops to assist education departments using the curriculum.	• Curriculum workshop in Nauru, Nov. 98. • 1999 Port Moresby and Manus workshop plans will be set by 12/15/98.
SPaRCE (Schools Of The Pacific Rainfall Climate Experiment	• Support SPaRCE program with small funding grant from 1994 to present. • Assisted in enrollment of schools in the program; All Manus and Nauru high schools have joined program. • Funding support has been used for development of automated school weather stations and advanced equipment, and also for participation in and joint sponsorship of in-service	• Reinstate contract by 12/31/98 with scope of work for 2 years.

	training.	
Newsletters	• Planning and scoping.	• Draft design by 10/30/98. • Complete design 10/30/98. • Complete Issue #1 12/15/98, distribution plan. • Issue #2 drafted 1/30/99; • Issues to be shipped for distribution at each location quarterly (Jan 15, Apr 15, Jul 15, Oct 15).
Material Support	• Improvement of material and equipment in the schools close to the ARCS-1 sites in Manus. Provided: books, video resources, automated weather stations and equipment, and supplies	• Finalize book shipment (donated books from the TWP team) to Manus by 9/15/98.
Teacher Training	• Two teachers sponsored, through SPaRCE, to attend the Pacific Education Conference in Palau in 1995. • Held an in-service training in Manus for all science teachers and senior education administrators to learn about SPaRCE and the ARM program. Funded PNG NWS Director's travel to this training.	• See implementation workshops.
ARM Resources	• Conducted tours for teachers and students at the Manus site, and trained the NWS Observers to conduct tours to promote understanding of the ARM program, and of general issues with climate and climate change. • TWP scientists and technicians have visited schools on numerous occasions, giving presentations to faculty and also helping teachers troubleshoot computers and equipment issues.	• Continue TWP site tours. • Train Nauru Observers to conduct site tours. • TWP installation team will visit schools and present ARM program to faculty and classes during Nauru installation in Oct/Nov 98.
Public Relations	• Drafted TWP PR plans for both PNG and Nauru in conjunction with on-site colleagues in the relevant government departments. • Other activities include Manus PNG: host tours, numerous radio interviews.	• Finalize PR plans for Manus and Nauru by 11/30/98. • Conduct TV/radio interviews in Nauru during installation. • Attend local meeting for PICCAP (Pacific Island Countries Climate Assistance Program) in Nauru. • Compile and distribute Nauru PR pkgs by July 98.

		• Send PR packages to PNG NWS Head Office by 1/30/99
Technical Training	• Developed technical training plan for PNG NWS with on-site staff, the PNG NWS head office, and TWPPO. The plan is under development with the Nauru staff supervisors.	• Computer training for all Manus Observers by 12/15/98. • Mgmt training for Officer in Charge, Manus • Continued technical training for NWS technical staff at Manus Aug 98. • Finalize Nauru Training Plan 10/30/98. • WMO training for Nauru Observer #2 Sept.98. • ARCS2 On-site Observers technical training during installation Oct/Nov 98.

7.0 DISTRIBUTION OF DATA

During January –June 1998, the following data sets released:

Manus:

February 1997
March 1997
April 1997
May 1997
June 1997
July 1997
August 1997
September 1997
October 1997
November 1997

Specific information on data availability by instrument and day can be found at: www.dmf.arm.gov.

Available data can be obtained from the ARM Experiment Center by contacting

ARM Experiment Center Manager, Ms. Robin Perez
robin.perez@arm.gov

ACRONYMS

ACCESS	Automated Communication Control and Environmental Supervision System
ADaM	ARCS Data and Management System
ARCS	Atmospheric Radiation and Cloud Station
ARM	Atmospheric Radiation Measurement
ATLAS	Atmospheric Laboratory for Applications and Science
AVHRR	Advanced Very High Resolution Radiometer
AWOG	ARM Ocean Working Group
BBSS	Balloon Borne Sounding System
BNL	Brookhaven National Laboratory
CLASS	Cross-Chain LORAN Atmospheric Sounding System
CSP	Combined Sensor Program
DOE	U.S. Department of Energy
ECMWF	European Centre for Medium-Range Weather Forecasts
ENSO	El Niño Southern Oscillation
GNDRAD	Groundward Looking Radiometer Stand
GOES	Geostationary Operational Environmental Satellite
HRPT	High Resolution Picture Transmission
IOP	Intensive Operational Period
IRT	Infrared Radiometer
ISS	Integrated Sounding System
JAMSTEC	Japanese Marine Science and Technology Center
MAS	Manus
MFRSR	Multi-Filter Rotating Shadowband Radiometer
MPL	Micro-Pulse Lidar
MWR	Microwave Radiometer
N	Number
NCAR	National Center for Atmospheric Research
NIP	Normal Incidence Pyreheliometer
NOAA	National Oceanic and Atmospheric Administration
NSA/AAO	North Slope of Alaska and Adjacent Arctic Ocean
NWS	National Weather Service
PIR	Precision Infrared Radiometer
PMEL	Pacific Marine Environmental Laboratory
PNG	Papua New Guinea
PSP	Precision Spectral Radiometer
RACE	Remote Accessibility Communication Equipment (ACCESS)
RASS	Radio-Acoustic Sounding System
RESET	Regional Service Team
SAM	Supervision and Management (ACCESS system)
SE	Significant Event
SGP	Southern Great Plains

SKYRAD	Skyward Looking Radiometer Stand
SpaRCE	Schools of the Pacific Rainfall Climate Experiment
SPREP	South Pacific Regional Environment Program
SST	Sea-Surface Temperature
TAO	Tropical Atmosphere-Ocean
TOCS	Sea-Surface Temperature
TAO	Tropical Atmosphere-Ocean
TOCS	Tropical Ocean Climate Study
TOGA	Tropical Ocean and Global Atmosphere
TOGA COARE	Tropical Ocean Global Atmosphere Coupled Ocean-Atmosphere Response Experiment
TRITON	Triangle Trans-Ocean Buoy Network
TWP	Tropical Western Pacific
VCEIL	Vaisala Ceilometer
VISSR	Visible and IR Spin Scan Radiometer
VOS	Volunteer Observing Ship
WMO	World Meteorological Organization
WSI	Whole Sky Imager

APPENDICES

A. Manus Site Map